

# Development of fuel and heat management systems for liquid hydrogen powered aircraft

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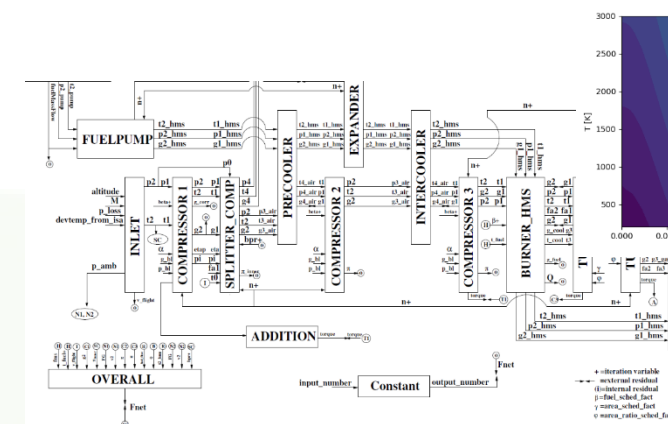
## ENABLE H2



This project has received funding from the EU Horizon 2020 research and innovation programme under GA n° 769241

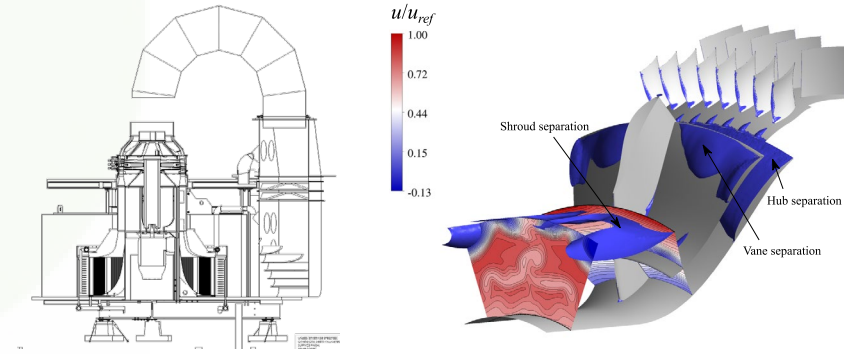
## Phase 1: Conceptual Design

- System Model: Adaptation of components for cryogenic fuel simulation.
- Parametric Studies



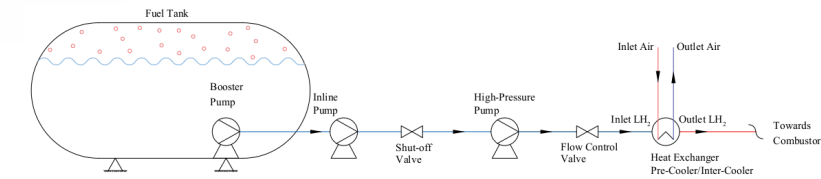
## Phase 2: Preliminary design and validation

- Heat transfer, flow turning at representative conditions
- Core exhaust heat rejection
- Core flow cooling
- Low speed high Reynolds number annular test facilities



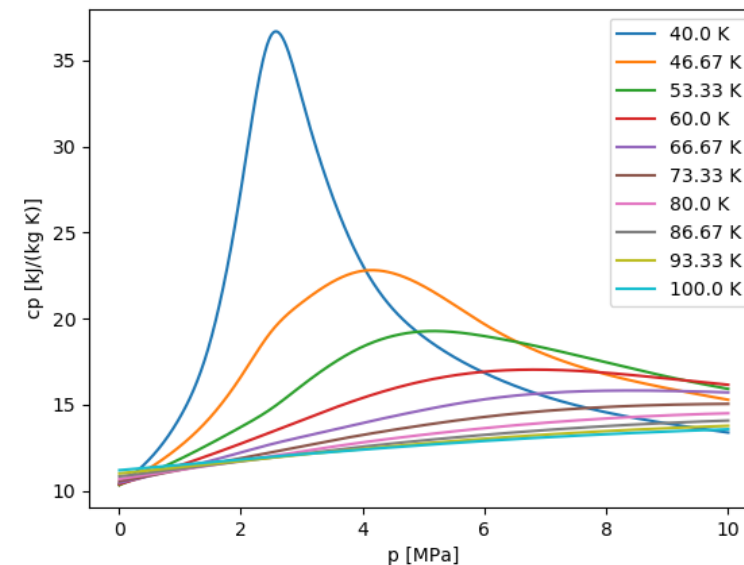
## Phase 3: Heat Management System

- Final heat management system to be down-selected
- Optimize solutions applicable to the ENABLEH2 aircraft concepts
- TRL 2 achieved



# Heat management potential

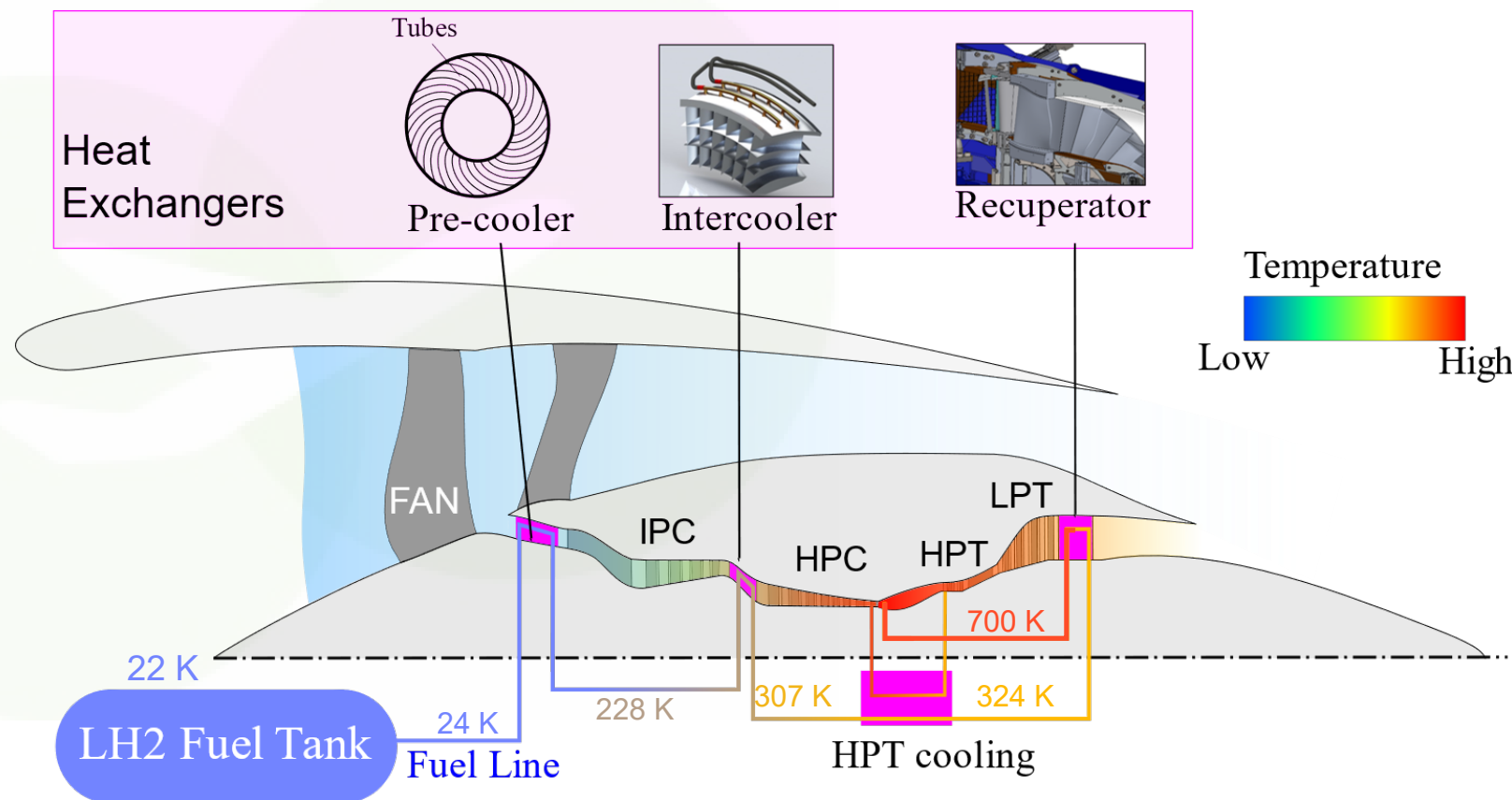
- High specific heat
- Cryogenic storage temperatures (22 K)
- From cryogenic to up to 800-1000 K about 14 MJ/kg can be recovered



**Fig:** Hydrogen specific heat variation with pressure and temperature

# Heat management potential

- Multiple options for heat recovery from the cycle exist
- Different designs can be explored
- Impact of tank and sub-system performances must be taken into consideration
- Engine performance, CFD and experimental work



**Fig:** Cross-sectional meridional cut of a turbofan engine, including possible locations for core heat rejection to the hydrogen fuel



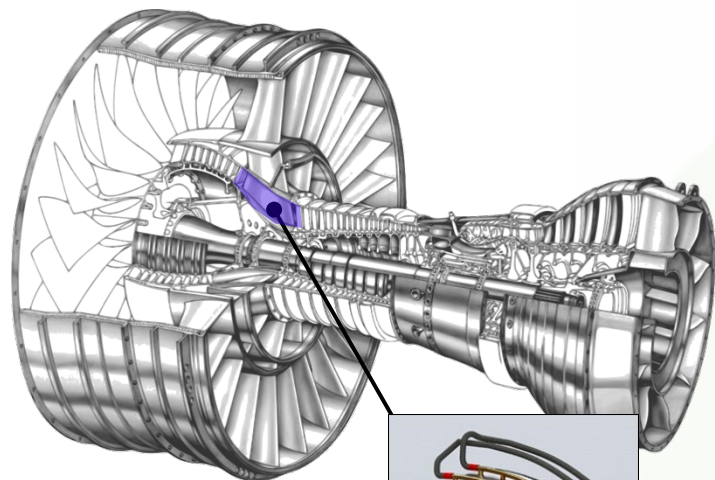
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# Vane-integrated HEX

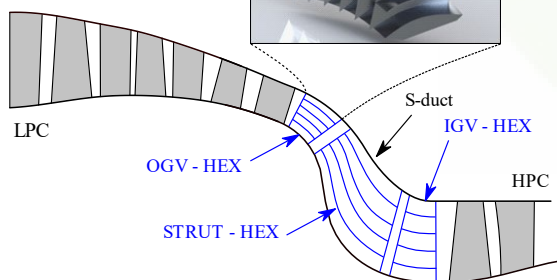
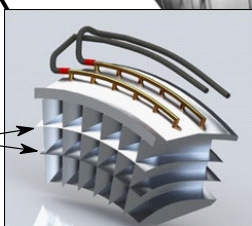


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- Compressor vane integrated HEX
- Enhanced radial turning
- Reduced Core size



Splitter-vane



$u/u_{ref}$

1.00

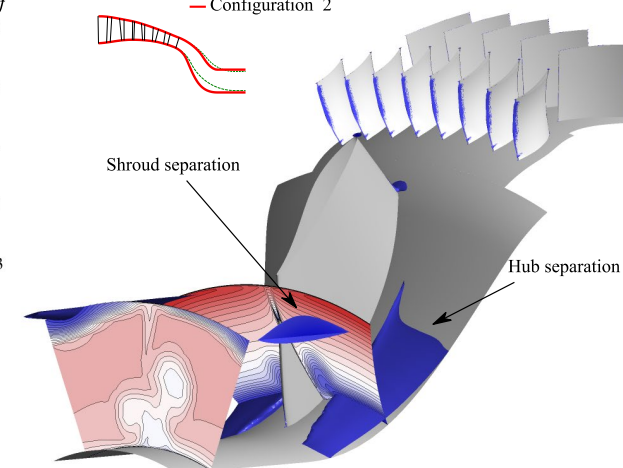
0.72

0.44

0.15

-0.13

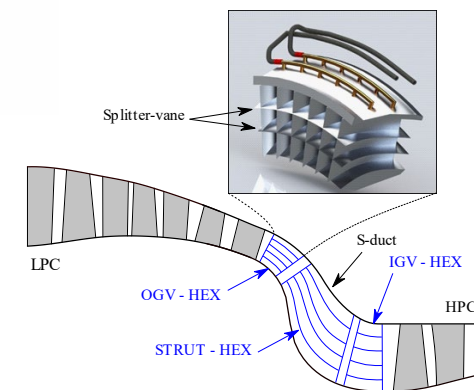
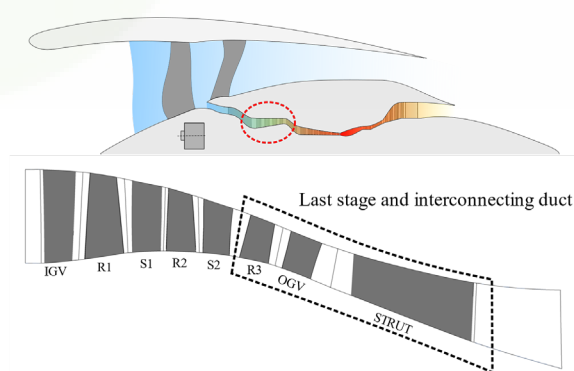
Configuration 2



Conventional duct



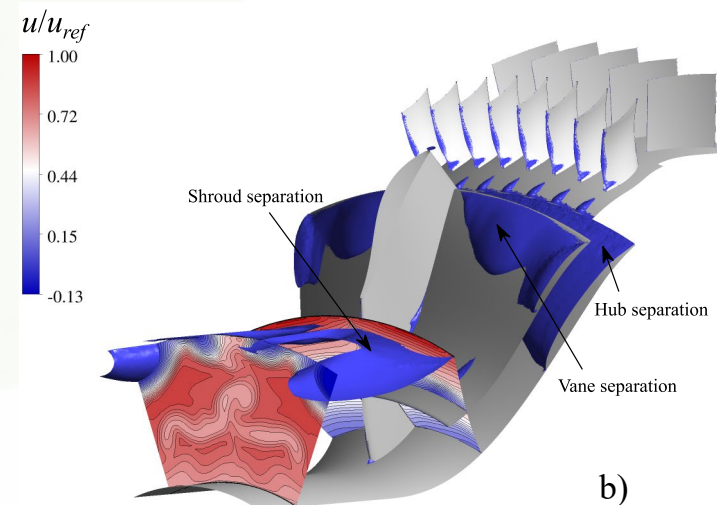
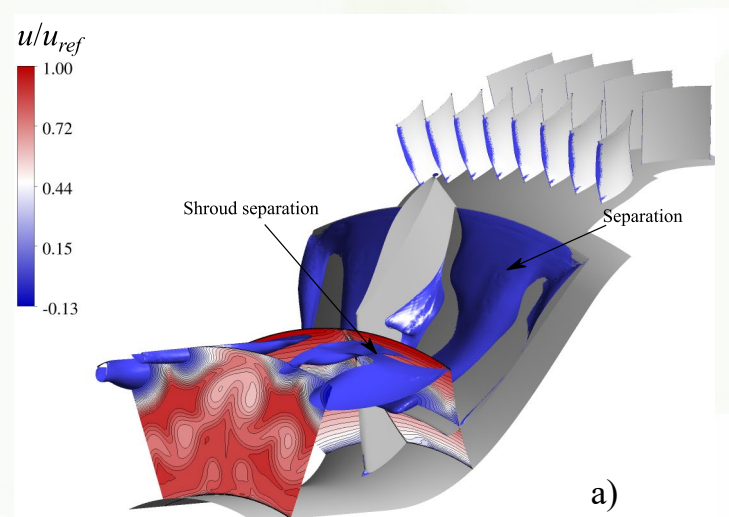
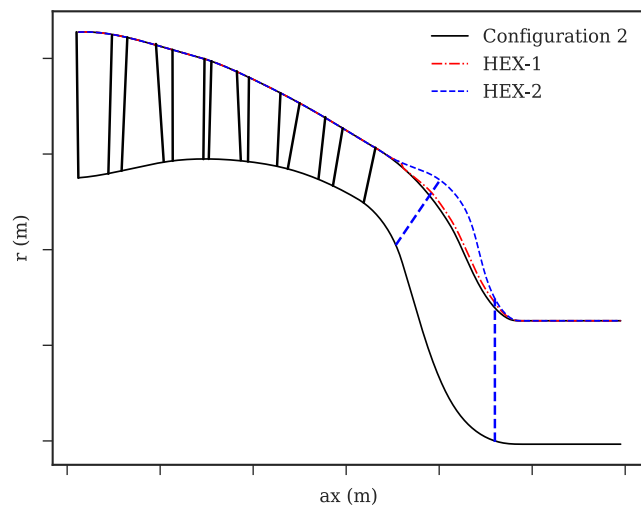
New duct design



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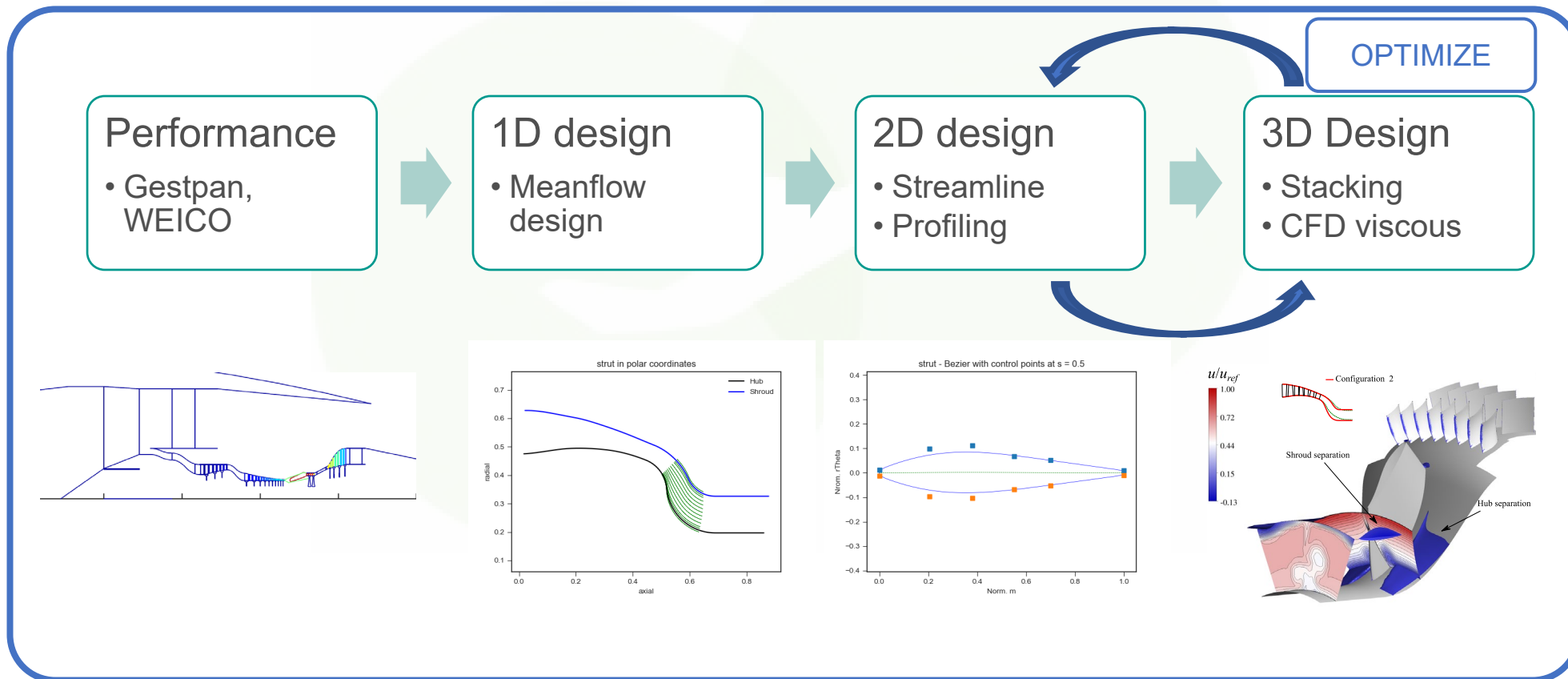
# First insight into the design



**FIG:** Normalized axial velocity computed for the HEX-1 (a) and HEX-2 (b) duct design. The Iso-surface shows regions of flow separation.



# Design tools



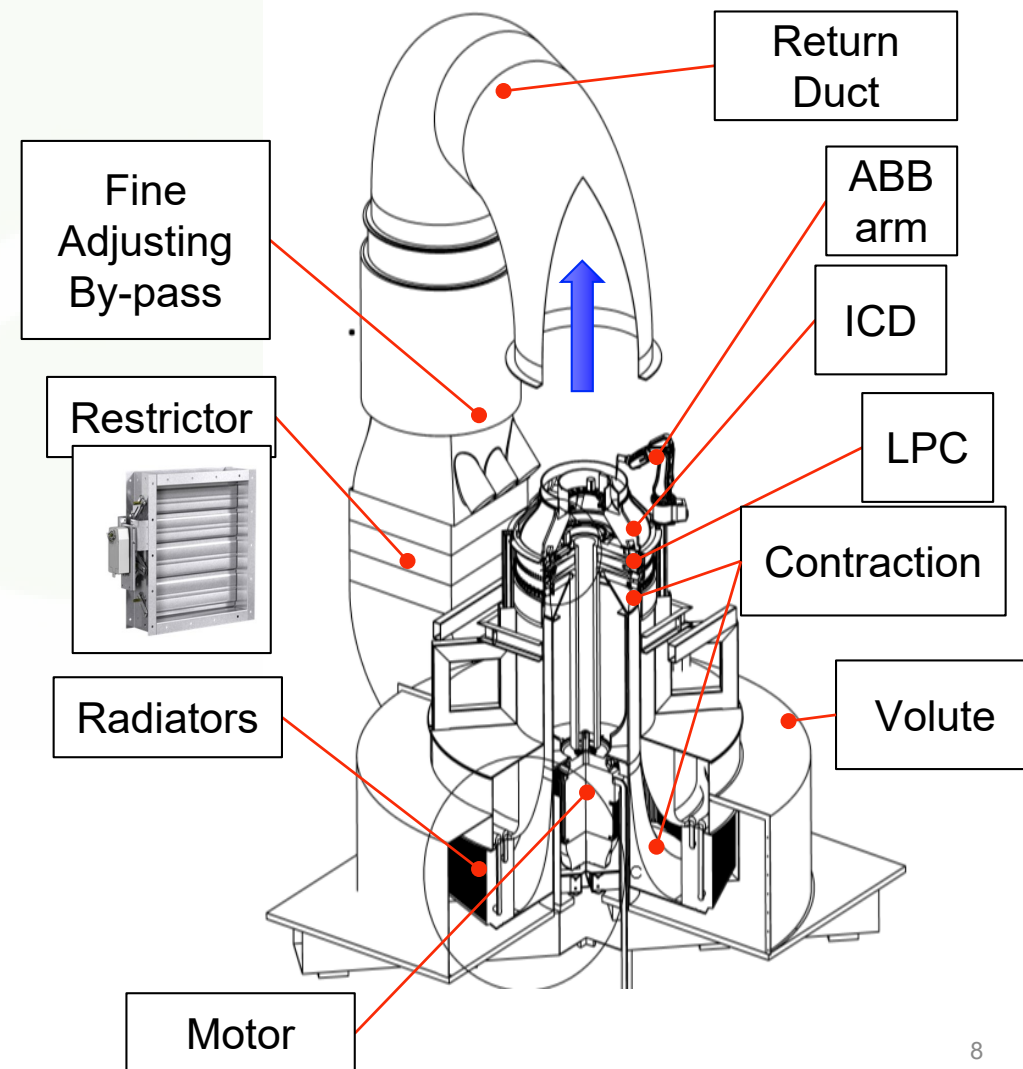


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# Compressor rig



- 2.5 stages, low-speed
- Vane integrated cooling system
- Calibration
  - Heat transfer
  - Transition







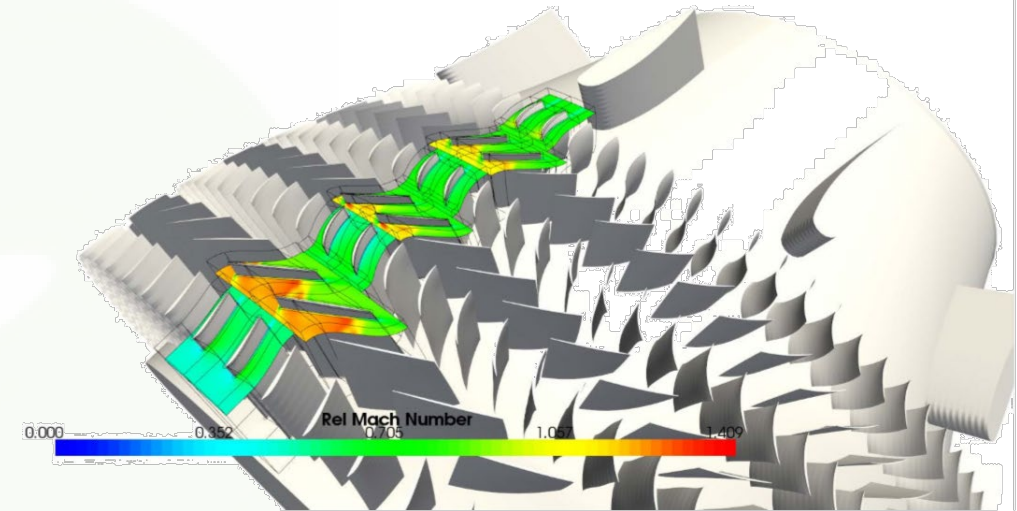
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# Compressor rig



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- Version VINK (National Collaboration; GKN, KTH, Chalmers, LTH, Swerea)
- Geared turbofan, 70klb thrust
- Replicate similitudes:  $Re$ ,  $\phi$  (flow coef.),  $\psi$  (stage loading), hub-to-tip ratio,  $de$  - *Haller* number



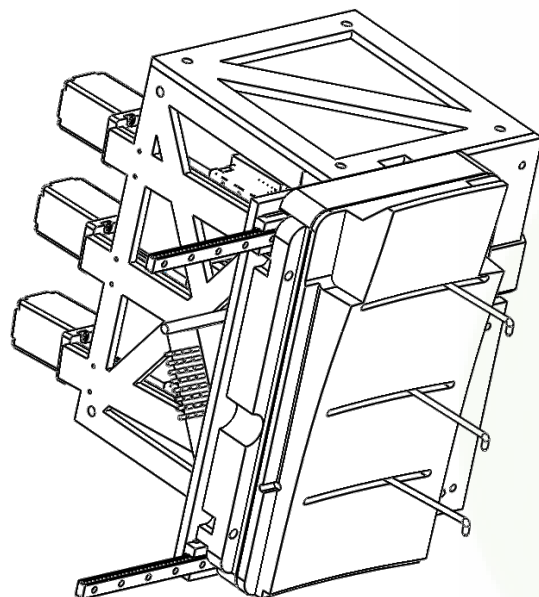


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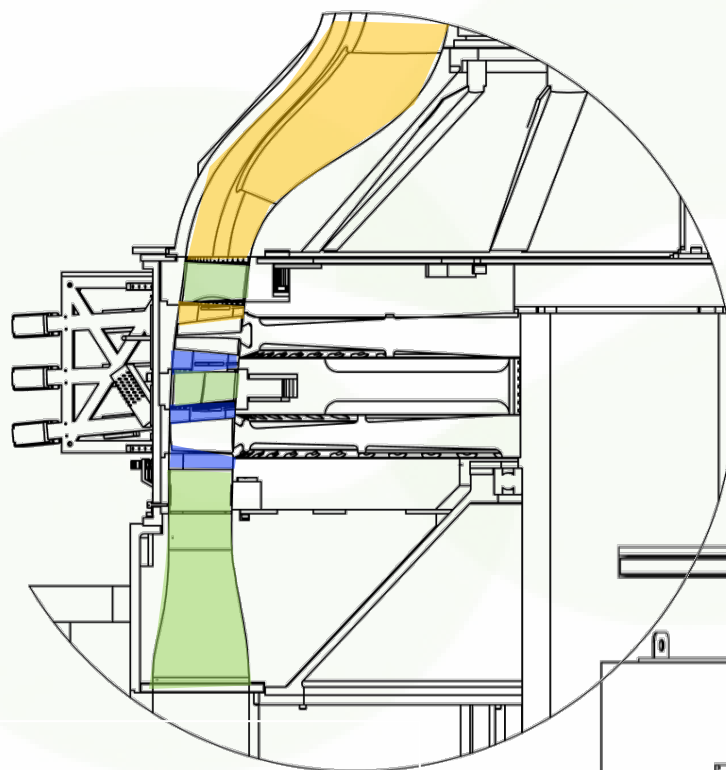
# Instrumental Overview



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Easy accessible

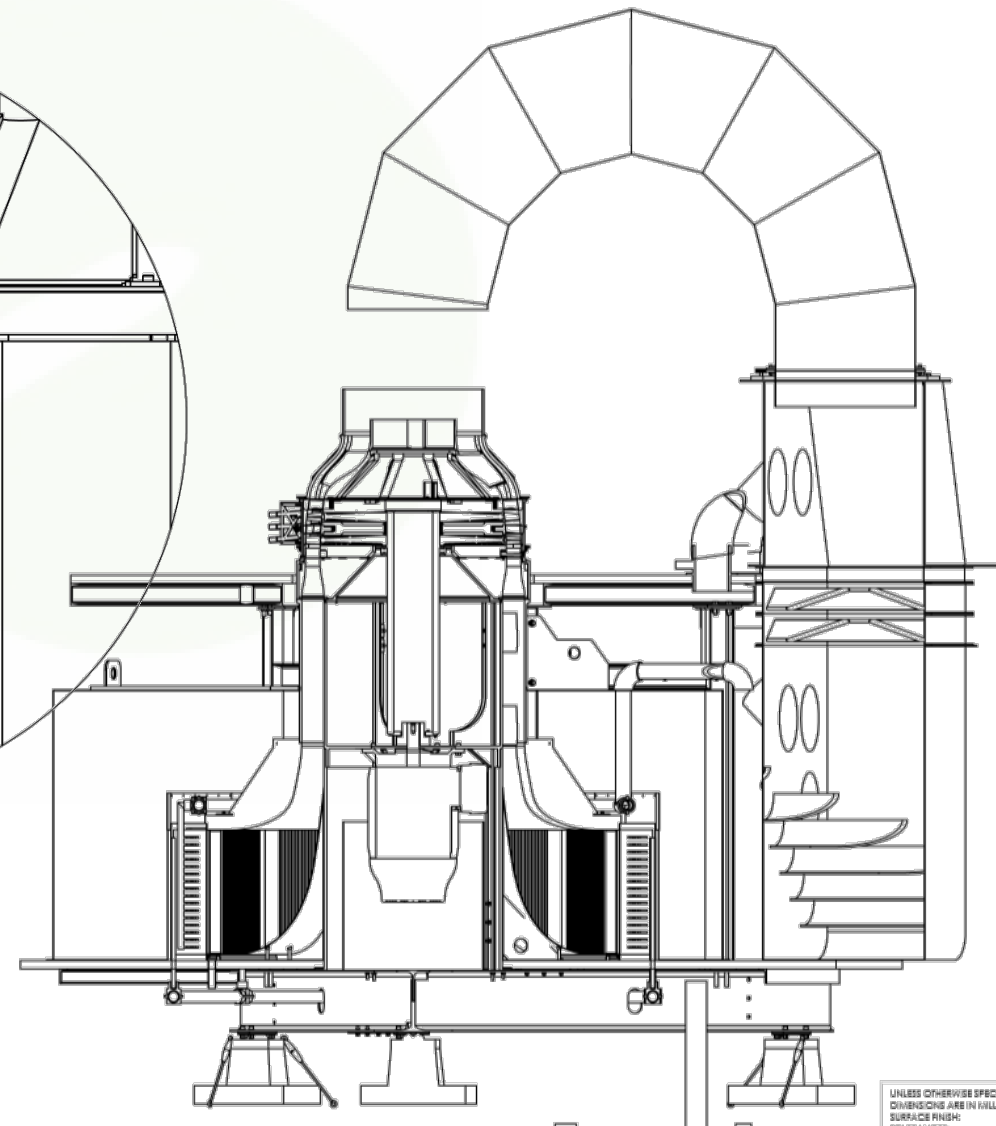


360°

Static mount

- Pressure taps
- Prandtl tube/rakes etc

Sector Access



UNLESS OTHERWISE SPECIFIED:  
DIMENSIONS ARE IN MILLIMETERS  
SURFACE FINISH:  
100 20 0.0001



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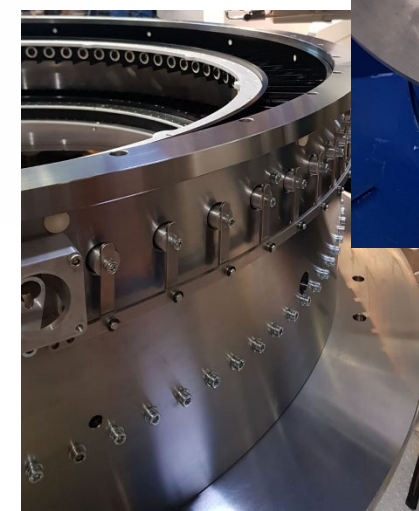
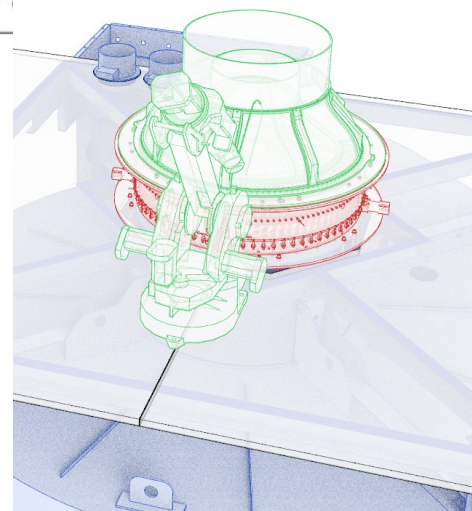
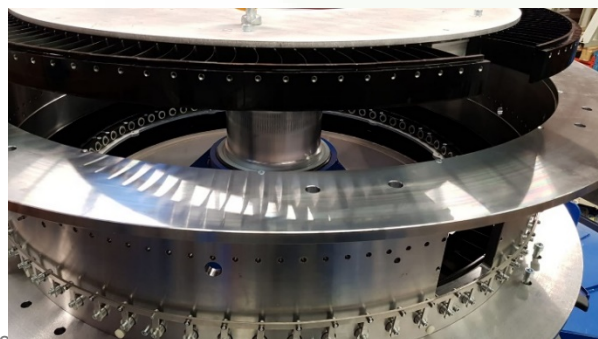
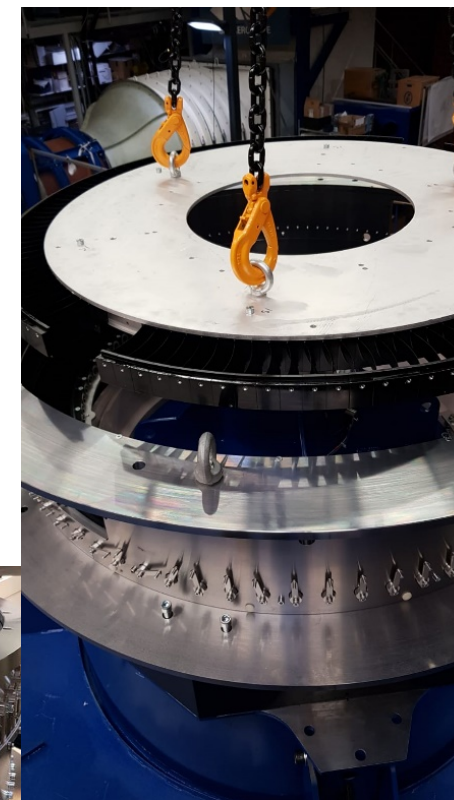
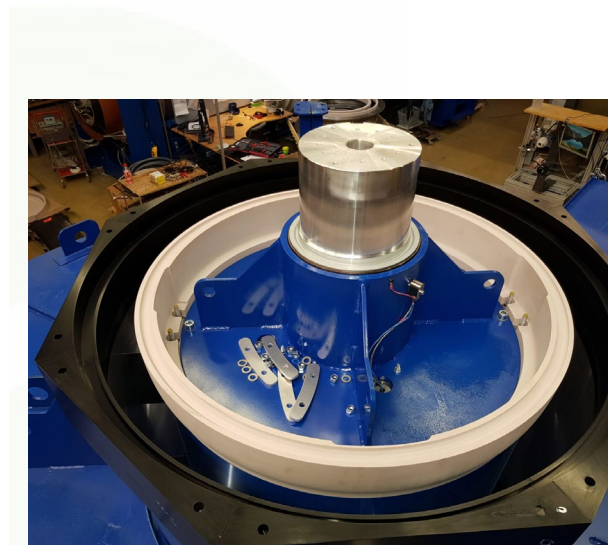
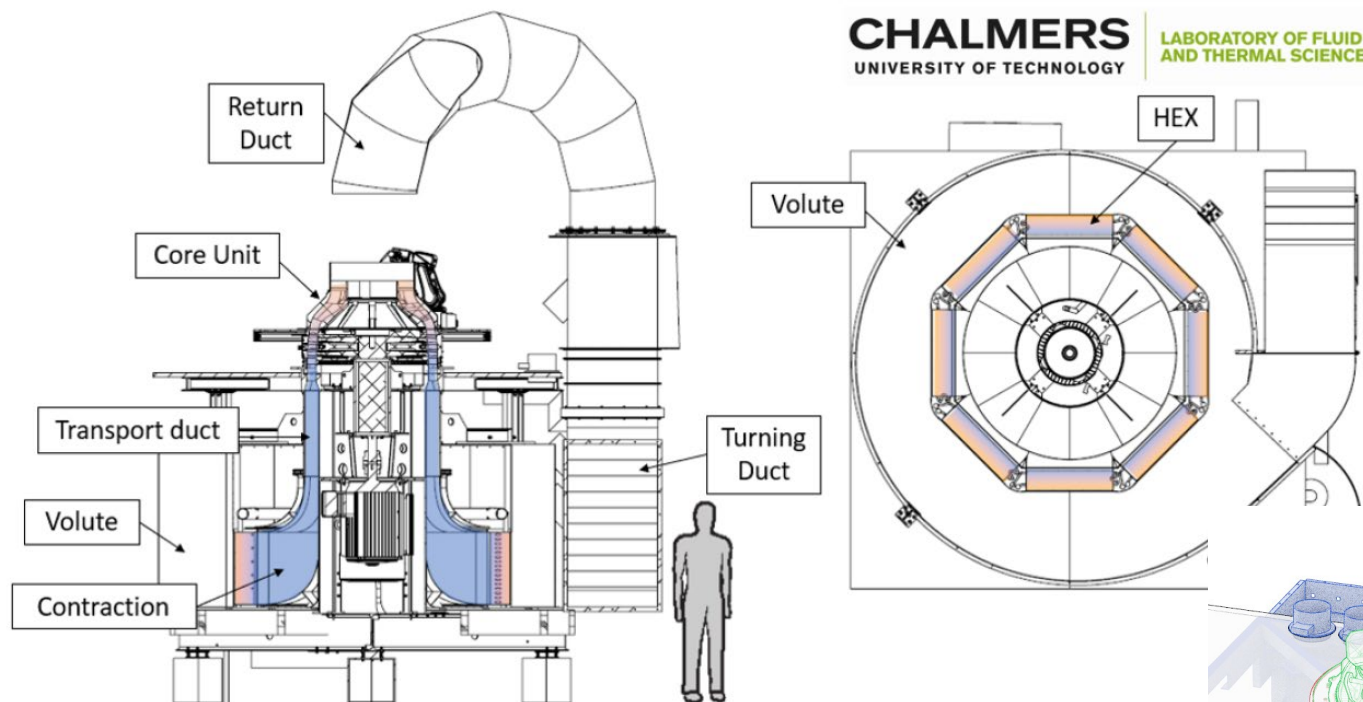


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# Teaser



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# Future steps



- Validation data
- Preliminary design of vane integrated HEX
- Test design in the new facility
- Optimize the design
- Develop and optimize fuel and heat management systems applicable to different ENABLEH2 aircraft concept





# ENABLE•H2

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**Thank you!**

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London  
South Bank  
University



Heathrow



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